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AUTOMATIC STEP THREADING OF BREECHBLOCKS

C. Rose

June 1977



US ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report details the engineering design, development and application of equipment to produce step threads (constant lead thread on two or more diameters) on the breechblock of cannon. The equipment uses a blade type tool with the part being threaded through shaper type cuts until finish size is reached. The use of this equipment will reduce the floor to floor time from 7.5 hours to 2.0 hours while producing better thread finishes and more accurate dimensional sizes.		

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DEPARTMENT OF THE ARMY
WATERVLIET ARSENAL
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3 January 1977

SUBJECT: Final Technical Report

TO: Commander
U.S. Army Armament Command
ATTN: AMSWE-PPW-PB
Rock Island, Illinois 61201

Project No: 6716771

Project Title: Application of an Improved Machine for Automatic Step Threading of Breechblocks and Rings.

Project Officer: C. Rose

Statement of the Problem: To develop the specification requirements of a step threading machine for the 175mm and 8" breechblocks and test machine and develop operating parameters.

Background and Introduction: The "step-thread" is a thread design in which the mating surfaces of the breechblock and ring are threaded on two diameters generated from the same axial position. The purpose of stepping the thread is to provide the maximum possible surface engagement area with a minimum rotary movement for engagement and disengagement of the block and ring (Figure 1).

The conventional method of machining step-threads in rings and blocks is by use of an engine lathe (Figure 2), whose cross slide is automatically traversed "in" and "out" for threading varying diameters or sectors of the rotating workpiece. The lathe's cross slide movement is cam actuated "in" on the cutting stroke and spring actuated on the return or "out" stroke. Failure of spring reaction for any reason will cause the cutting tool to strike the subsequent step, with catastrophic results, usually a broken tool or damaged workpiece. One (1) RPM is the normal machine speed at which the operation is performed (4-5 sfm) on the 175mm and 8 inch; at higher RPM, the spring reaction time is not rapid enough to retract the tool for threading the next larger step. The complete threading operation is approximately seven and one half (7-1/2) hours for a 175mm breechblock.

It was believed that a new approach in threading, in essence a rotary shaper, whereby the entire sector would be machined to full thread form and depth before proceeding to the next sector, would be the answer for rapidly machining step-threads.

During WWII, an attempt was made by Watervliet Arsenal to speed up production and overcome the bottleneck problem associated with the stepping lathe procedure. The LaSalle Engineering Co. of Chicago was consulted and proposed a broad bladed cutter similar in design to a conventional thread chaser. This cutter would oscillate through the complete width of one sector, completely finishing all the threads on that sector before proceeding to the next sector. The sequence would be repeated until all sectors were completely threaded. A machine was constructed at Watervliet Arsenal and completed in 1943.

Although the fundamental method was sound and the equipment would produce a thread, inherent design defects in the machine prevented the system from ever becoming reliable production equipment. One of the most troublesome aspects was that two different size tools were used for the different diameters of each component, causing thread lead problems. Also, the feed rate was erratic causing an intolerable situation in this operation. At the end of WWII, the machine was eventually discarded as surplus.

During the 25 year span from its conception, this threading innovation was discussed many times regarding its potential if the equipment's defects could be resolved. However, continued anticipation of a "break-through" in weapon design whereby step threads would no longer be required, prevented any resolution of the step-thread machining problem until initiation of the current project.

Approach to the Problem: Using FY69 funding a specification was prepared and a prototype machine purchased to produce step threads in the 175mm and 8" breech ring using a rotary thread shaping method. Using this method each sector was threaded to desired depth before proceeding to the next sector. Although this machine was capable of only roughing the threads, it resulted in reducing the threading time by 4 hours.

Based on the data obtained through the procurement and testing of this machine it was decided that the rotary shaper approach should be applied to the machining of the 175mm and 8" breechblock step threads. A machine concept and the specification were prepared (RDD 72-101 available on request) for the purchase of a machine to perform this operation. With this machine, the component is mounted upon the machine spindle and the component oscillated while the tools are fed out to machine the required thread depth and form. In addition, provisions were made in the specification that allow for the finishing of the threads using only one tool. This eliminates the problems of maintaining thread concentricity and lead in the finish component, which were encountered in the prototype ring machine.

Description of Machine and Breechblock: In Figure 3, item 1 shows the 175mm/8" breechblock machined prior to step threading with all the interior and exterior diameters machined to finish size. Item 2 shows a completely threaded block ready to be qualified in the final inspection receiving gage. The block has a constant lead thread; however, the thread is machined on two different diameters.

Figure 4 shows a closeup view of the breech end of the block prior to threading. The three machined surfaces (Item 1) are necessary to assure parallelism between the muzzle or locating face and the breech face which is used for location during the step threading operation. The hinge pin hole (Item 2) is used during threading for a location pin to locate each block. The large lug (Item 3) is a clamping surface used to securely clamp the block in the threading fixture.

When the 175mm block is threaded in the conventional step threading machine the tool shown as (item 1) Figure 5, is used. This tool is form ground to machine one thread tooth and is fed into the component in increments of .001", traversing the full length of the component (14 revolutions) and repeating the sequence until the block is finished. Approximately seven hours is required for floor to floor operation. The threading tool used on the new step threader is a full form tool (Item 2) having all the teeth required to finish one complete sector. The machine oscillates the block back and forth in an action similar to a washing machine agitator, machining one sector at a time to size. In actual practice, two tools are mounted in heads 180° apart and two sectors are machined simultaneously to within .020" of finished size. During this rough machining, the block is oscillated at 20 oscillations per minute and the opposing tools are fed in at .002" per oscillation. One tool is then removed and replaced with a newly sharpened tool and the remaining .020" is removed to bring the component to finish size and complete thread form. This threading is also performed at 20 oscillations per minute with the feed reduced to .001" per oscillation for better finish and size control. The threading time is approximately 2 hours or a 5 hour savings over the current step threading method.

Figure 6 depicts a front view of the machine. Item 1 is the 30 HP Vari-drive motor unit, the main machine drive motor providing a variable oscillation rate from 0 to 25 oscillations per minute. Item 2 is the machine base which is a fabricated steel weldment, machined to the required tolerances. The crank pin (item 3) connects the rotary motion being produced by the gear reducer (item 4) into an oscillating motion required to rotate the breechblock past the stationary cutter to produce the step thread form.

Figure 7 is a view looking at the machine table and control station. The machine tool spindle (item 1) is shown with a partially threaded 175mm/8" breechblock secured on the threading fixture. A spray oiler (item 2) is provided on both threading heads to lubricate the ball feed screws, tool slides and wedges located in the threading heads. The levers (item 3) on the left and right of the machine control the positive stops for the right and left hand tools. These levers, when locked into the "in" position (closest to the machine spindle) stop the tools at the larger step thread diameter while in the "out" position stop the tools at the smaller step thread diameter. Item 4 on the left and right hand side of the machining heads are rotary limit switches having four normally open contacts. These safety switches were incorporated in the machine to assure that the component will not oscillate unless the locating pin which locates the block for threading the large or small sectors is in the correct position. This modification was made to the machine after delivery to Watervliet. If the tools are accidentally in position to thread the small step threaded diameter but the block is in a position to thread the large diameter, the machine will not start. This prevents tool and/or machine damage. Under the two covers (item 5) are the two stepping motors which provide the feed for the threading tools. Also, beneath the covers are two potentiometers which provide readings on the machine console showing the position of each tool. The machine console (item 6) and operator's control panel (item 7) will be discussed in the operation of the machine.

The machine tool spindle without a component is shown in Figure 8. The two clamping blocks (item 1) are used to securely clamp the component radially to eliminate the possibility of the component moving during the threading operation. The expanding sleeve (item 2) which is expanded by tightening the expansion nut (item 3) spreads into the bore of the breechblock to assure concentricity between the inside and outside diameter (item 4) threads on the machine spindle and clamps the breechblock securely to the fixture base. The sleeve (item 5) is used during the loading and unloading of the component to protect the threading tool (item 6) from accidental damage.

Figure 9 shows the machine tool spindle with the component in the threading position. The sliding wedge (item 1) locates in the hinge pin hole on the breechblock and the sliding wedge is expanded to align the breechblock properly on the fixture. The hex bolt (item 2) is one of two clamping screws shown as item 1 in Figure 8. Item 3 shows the partially threaded breechblock in the threading position with the clamp nut (item 4) tightened in place. The spindle support yoke (item 6) supports the spindle during threading and is clamped rigidly to the machine with clamp nuts (item 5).

Figure 10 shows the main electrical control panel with the door in the open position. In the lower half are the relays and motor starters used in normal machine operation. The stepping motor controller which provides for the exact feed cycles on the machine is shown as item 1. Item 2 is the balance resistor used in conjunction with the stepping motor. An exhaust fan is mounted at the top of the cabinet (item 3) to provide for proper temperature control of the electric components located within the cabinet.

Figure 11 is a front view of the machine console which contains controls that are normally fixed in one position during the operation of the machine. This figure will also be referred to in the following section entitled "Step Threading of 175mm/8" Breechblocks." The ammeter (item 1) shows the machine amperes required to machine the block and provides an indication of the condition of the tools and the depth of cut. The position of cutting head A is indicated by the digital readout (item 2) while the position of the B head is shown on digital readout (item 3). The controller for the feed of the machine tool is located on the console as (item 4). The depth of feed per cut is controlled by the feed control (item 5) and the retraction of the tool is controlled by the clear control (item 6). The actual amount the machine feeds or clears the tools is equal to the figure shown on the control divided by four (4). Example: 40 shown on the clear dial equals $40 \div 4 = 10$ or the head clears the workpiece by .010" when the tool is returning to the start position. To determine the actual tool feed, subtract the number on the clear dial from the number on the feed dial and divide by four. Example, using Figure 11, feed dial shows 44, clear dial shows 40. Using the feed of 44 subtract 40 leaving 04 divided by 4 would give a feed of .001" per oscillation. Depressing the button marked either A or B and depressing the Run button will cause the head to move continuously either in the feed or clear direction depending upon the position of the feed/clear switch. If the Jog button is depressed in conjunction with the A or B button the threading heads will move only .00025" every time the Jog button is depressed. Thus, through the use of the Run and Jog button, the threading heads can be accurately positioned to any position required by the operator.

To determine if the feed unit is moving at its set rate depress either or both buttons A and B, and push the Index button. The feed on the digital readout should advance the amount shown on the feed dial every time the Index button is depressed.

The pendant control station (Figure 12) shows the various switches and push buttons used in the operation of the machine tool. The operation will be discussed under the section titled "Step Threading of 175mm/8" Breechblocks." The top five buttons in Figure 12 and the one on the left side of the second row are lights which light when that function is in operation.

The remaining switches and push buttons are properly labeled and will be explained in the following section.

STEP THREADING OF 175MM/8" BREECHBLOCKS

A. Preparing Block for Step Threading

1. Check block to determine if three spots have been milled parallel on breech face of block. Length from milled spot to muzzle face of block should be $7.774 \pm .001$. Any variance should be marked on the breech face and an adjustment made by adjusting the thread location wheel located to the right of the machine console.

2. Place locating template on block, locating template from hinge pin hole and scribe thread center line location.

3. Place plug in cross head hole.

B. Mounting Block on Step Threader

1. Place special sleeve over the block locating shaft to protect cutter while assembling breechblock on the threading fixture.

2. Oil expanding collet prior to loading breechblock.

3. Using special lifting device (F8763464T36D), lift block with crane and place block breech face down on threading fixture.

4. Insert locating pin in breechblock and fixture and tap sliding half of block to tighten block securely in fixture.

5. Tighten expanding arbor to centralize block using special spanner wrench.

6. Place clamp ring and nut on top of block.

7. Tighten clamping nut to clamp block to fixture using special spanner wrench.

8. Using crane, place shaft support yoke on fixture shaft. Place hex retaining nuts on yoke and securely tighten.

9. Tighten clamp bolt closest to the locating pin until some resistance is experienced.

10. Tighten opposing clamp bolt until block is securely clamped.

11. Using .002" shim, check to determine if block is clamped evenly against pad on bottom of fixture. If shim will go between blocks and pad, loosen and retighten block per instruction procedure in steps 4-9 described above.

C. Threading Block (Roughing Threads)

1. Using "Position Motor" switch on machine operating panel, index block until Head A is in position to thread sector having scribed location line.

2. Lock handles located under heads A and B in the "In" position (closest to center of machine).

3. On machine console place Feed/Clear switch in Feed position and Manual/Auto switch in Manual position and using Run and Jog buttons advance head until digital readout for both A and B heads shows .355.

4. Turn Oscillator selection switch on machine control panel in the Jog position. Jog block through one threading cycle to assure that tools are clear of breechblock.

5. On machine console, move Manual/Auto switch into "Auto" position and jog through one more cycle to assure the automatic feed is performing properly.

6. On the machine control panel, move the Oscillator switch to "Run", turn Coolant switch to "On" position and push the Oscillator Start button. Allow the threading cycle to proceed until the digital readout on the machine console reads .600 on both heads.

7. Using the thread location hook gage, check thread location and adjust thread location by turning the adjusting wheel located to the right of the machine console. Moving block down .001 will advance the Hook Gage 1/16 inch. Location should be on scribed line to 1/16 inch past the line.

8. On the machine console place Auto/Manual switch in Manual mode and Feed/Clear in Clear mode. Retract both heads until digital readout reads .580. Return Feed/Clear to feed and Auto/Manual to Auto. Move oscillator button located on operating panel to Jog and by pressing oscillator control button jog through one cycle to assure that the tools clear the previously cut thread. Move Oscillator control switch to Run and remove sufficient material to cut both sides of thread. Recheck thread location with gage and if necessary, repeat operations 7 and 8 until thread location is correct.

9. When thread location is correct, continue to thread opposing large step thread diameters until both digital readouts show .632.

10. On the machine console, place Auto/Manual switch in Manual position and Feed/Clear switch in Clear position. Hold A and B buttons in depressed position and press run button until both A and B readouts return to .000.

11. On the machine control panel, depress the button marked "Internal Gear Disengage" and rotate block 90° to new position using switch marked "Position Motor" until "Internal Gear Engaged" light comes on.

12. Repeat operations 3, 4, and 5, and proceed to machine thread until both digital readouts show .632.

13. Move positive stop handles located under heads A and B to retracted or out position.

14. Repeat operation 11 locating the block for threading the smaller step threads. With Auto/Man switch on Manual and Feed/Clear on Feed, advance tools until both digital readouts read .900. With Oscillator switch on "Jog", jog through one cycle to assure that the tools clear the thread blank and sufficient clearance is available at the end of the threading cycle. If clearance is not satisfactory adjust stroke of machine. Return Auto/Man switch to Auto and jog through one more cycle.

15. On the machine control panel, place the Oscillator switch on Run, press Oscillator Start button and allow tools to feed until both digital readouts show 1.164.

16. Repeat operations 10 and 11 locating the block for threading the last two small thread sections. Repeat operations 13 and 14. This will finish the roughing of the step threads on the breechblock.

17. Completely retract both A and B heads.

D. Finishing Step Threads.

1. Lock handles located under heads A and B in the "In" position (closest to center of machine).

2. On the machine console, place the toggle switch controlling the A head in the "Off" position since only the B head is used for finishing the step threads. Remove tool from B head and replace with newly sharpened tool. Sight the alignment by eye to determine if previously cut threads line up with tool. If not, make necessary adjustments.

3. Disengage internal gear by depressing the "Internal Gear Disengage" button located on the operating panel and using the "Position Motor" switch index block to start threading on the thread location sector.

4. Feed tool head B in until digital readout reads .620. Depress "Finish-Cut" button. Place Oscillator control switch on "Jog". Jog through one cycle to assure that tool clears previously cut threads. Place Auto/Man switch on "Auto" and "Feed/Clear" switch on "Feed". Jog through one more cycle. Place Oscillator switch on "Run" and proceed to cut until both sides of thread have been machined. Check location with hook gage (Drg. F6536236-T 51A) to determine thread location. If location is incorrect, repeat steps 7 and 8 of roughing threads. When thread location has been established, proceed to thread sector until tool hits positive stop (approx. .656 on digital readout).

5. Retract B head till digital readout reads .620. Index block as described in paragraph 11 of roughing threads to next larger diameter step. Jog through one cycle to determine if tool clears previous cut thread. Place Feed/Clear switch in "Feed" position and jog through one more complete cycle. Place Oscillator in "Run" position and machine thread to positive stop (approx. .656 on digital readout).

6. Repeat operation 5 until all four large thread diameters are complete.

7. Retract tools till digital readout reads .350. Disengage "Internal Gear" and index block to thread small step threaded diameter. Advance B tool until digital readout reads 1.150. Place Oscillator switch, located on machine control panel, in "Jog" position and place Feed/Clear switch in "Feed" position and Man/Auto in "Man" position. Jog block through one cycle to assure tools clear block. Place Man/Auto switch in "Auto" and jog through one more cycle. Turn Oscillator switch in "Run" position. Start cutting action and continue until positive stop is contacted (approx. 1.186).

8. Repeat operation 7 until remaining three thread sections are machined to finished size. Retract tool B till digital readout shows .000.

E. Removing Block From Machine

1. Depress "Internal Gear Disengage" button and index block until thread location sector is in the threading position.

2. Remove hex nuts holding support yoke in position. Using crane, remove yoke from machine.

3. Release both clamps which clamp on locating pin.

4. Using tapered wedge, release location block from hinge pin hole.

5. Release and remove clamping nut from top of block.

6. Release nut to contract the expanding arbor to centralize the block.

7. Place special sleeve over block locating shaft to protect cutters during block removal.

8. Using special lifting device, remove block from machine using overhead crane.

9. Check thread for size and remove plug from cross head hole.

Conclusions: Fifteen 175mm breechblocks were machined to establish machining parameters and prove the reliability of the thread shaping principle. Although the initial cost of the blade-type tools is much higher than the conventional tools, the cost of regrind and the expected life of the blade-type tool results in the total cost of the two types of tools being approximately equal. The time required to thread a breechblock conventionally is 7.5 hours.

An additional operation is required to mill the three spots on the breech face of the block prior to step threading. It is estimated that .5 hours is the maximum time required to machine the three spots. Including this time in the step threading operation, the combined time should be approximately 2 hours or a 5.5 hour saving.

Project Leader

Charles H. Rose
Charles H. Rose

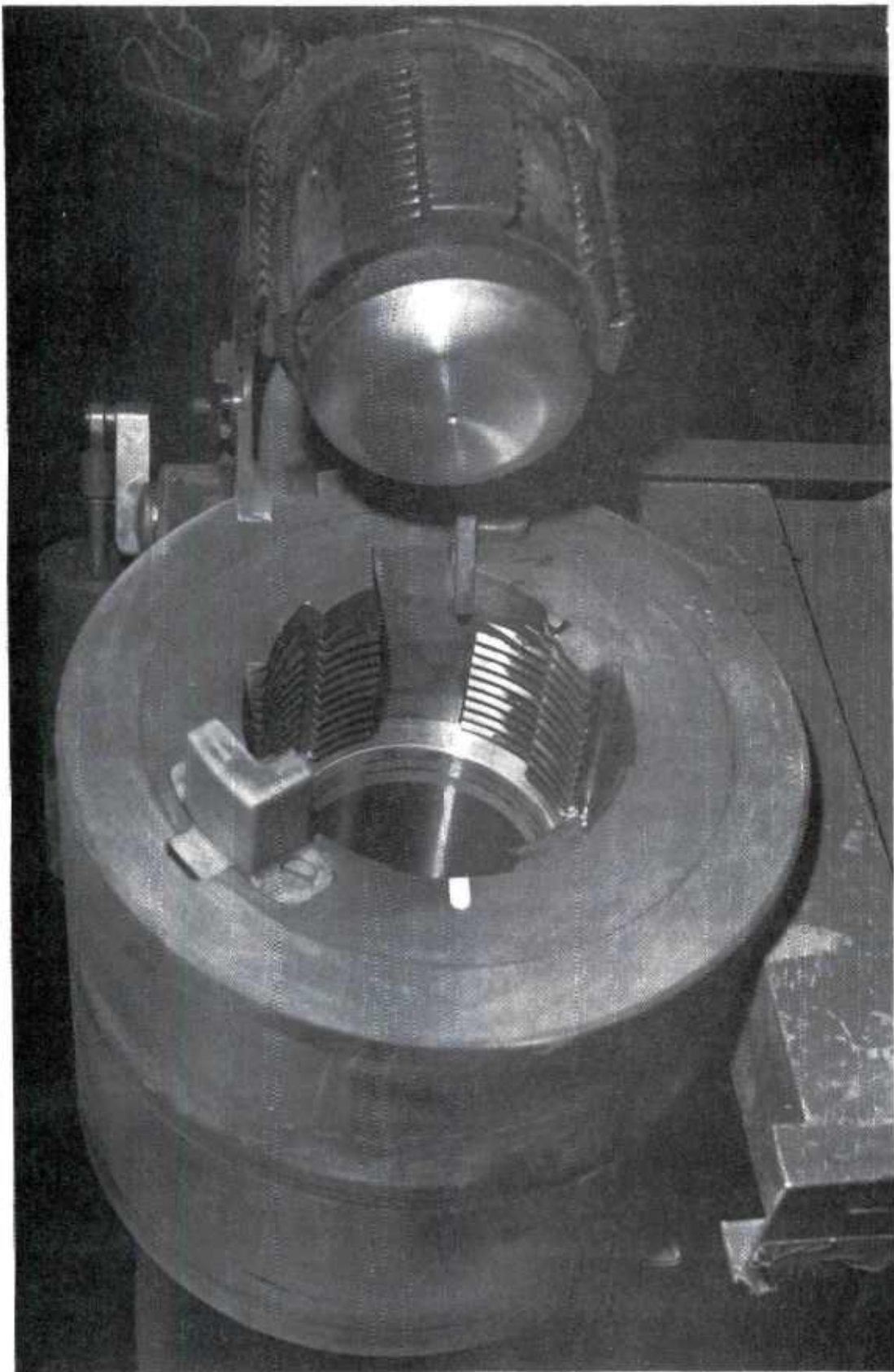


Figure 1. 175mm M113 block and ring assembly.

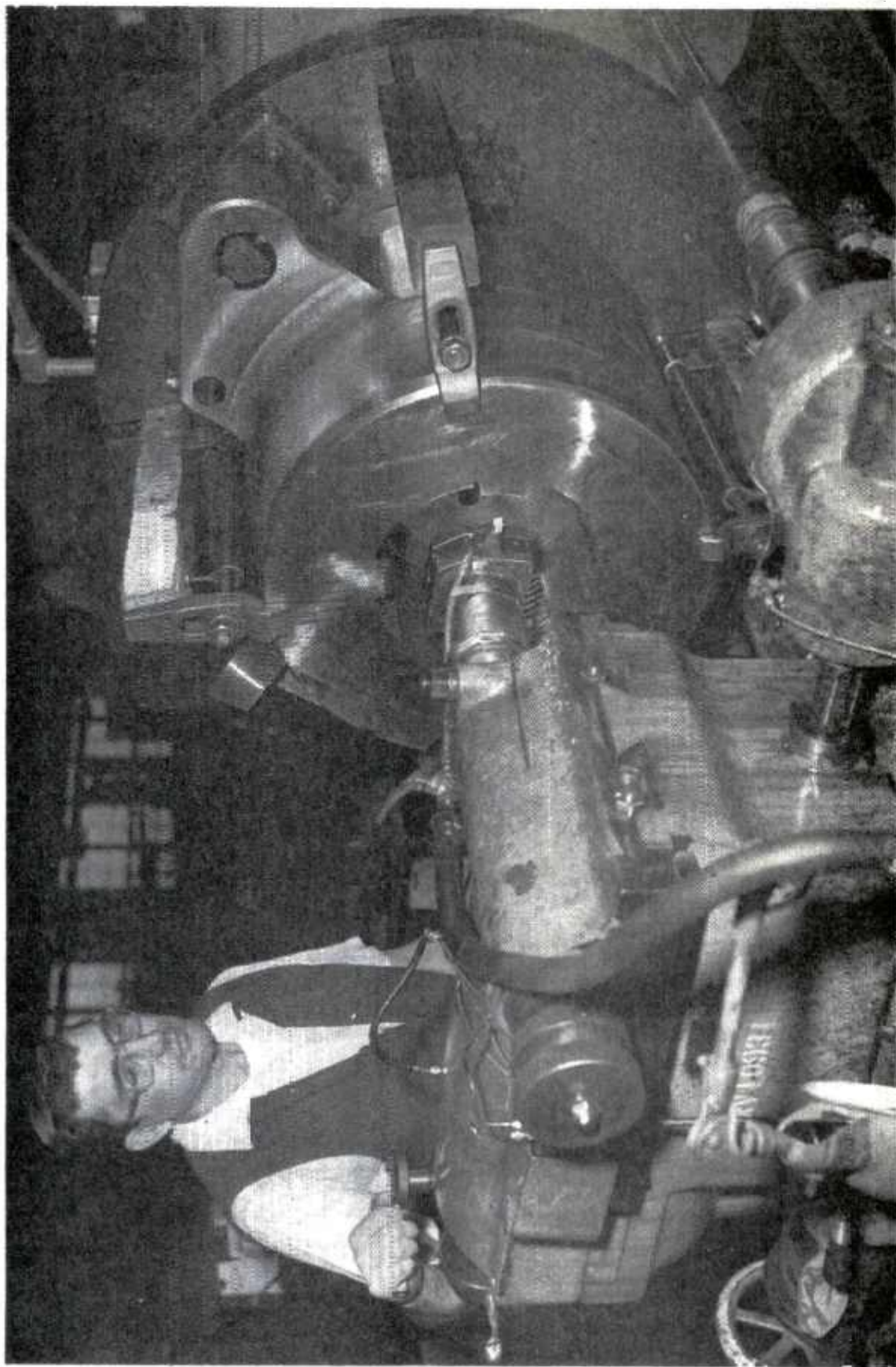


Figure 2. Step thread lathe.

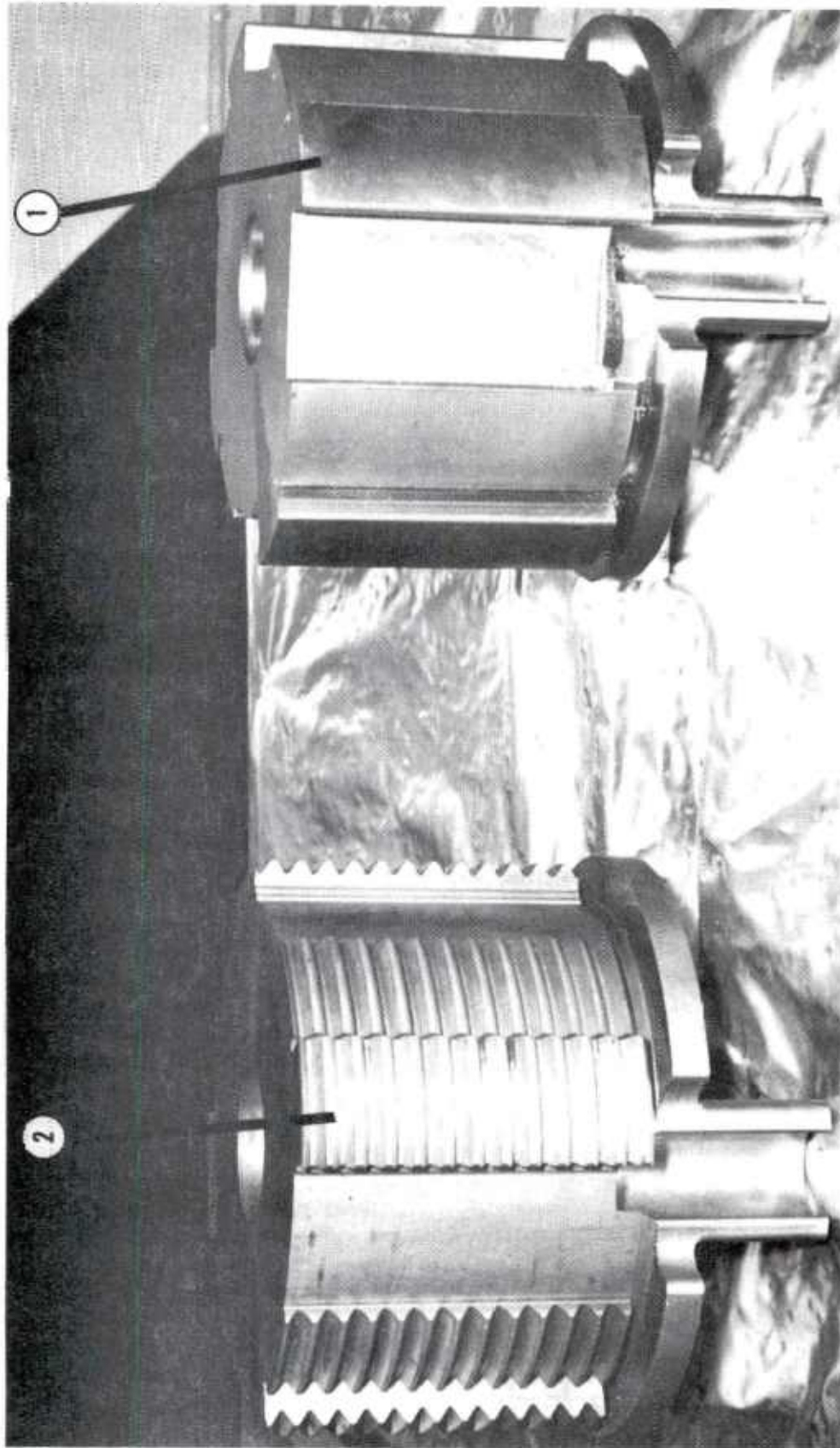


Figure 3. 175mm breechblocks.

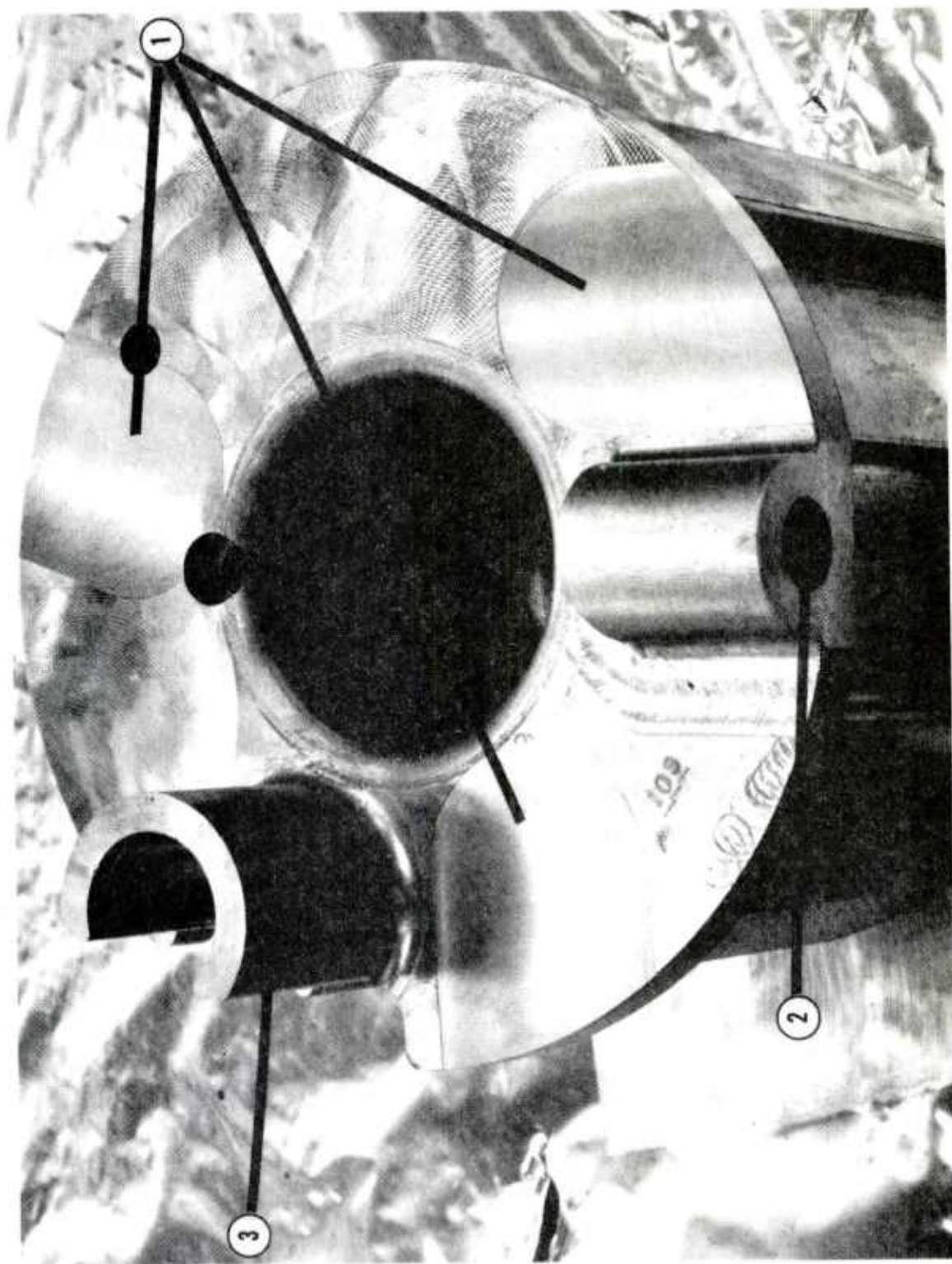


Figure 4. 175mm/8" breechblock (breech end).

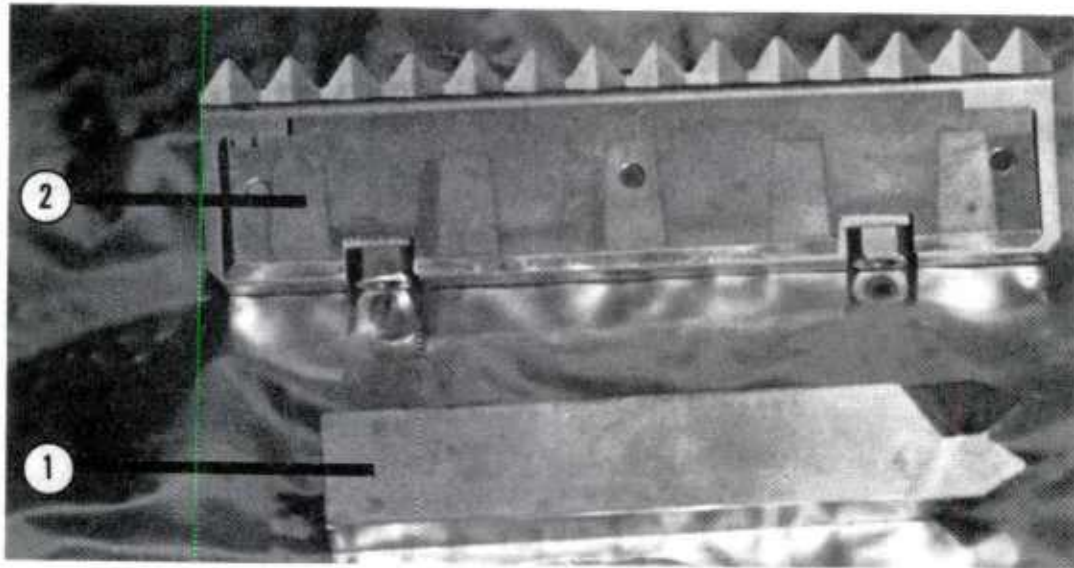


Figure 5. Threading tools.

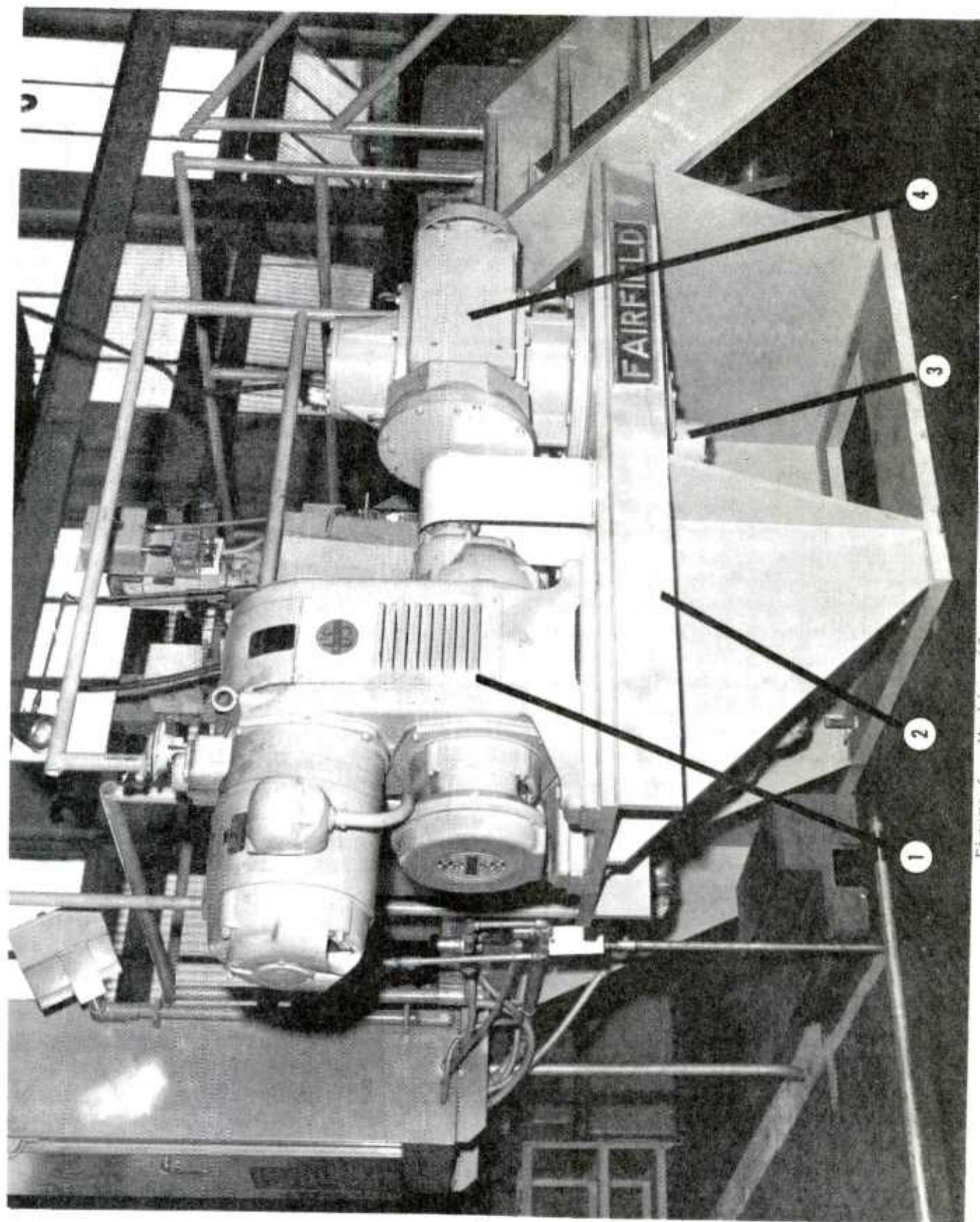


Figure 6. Machine (front view).

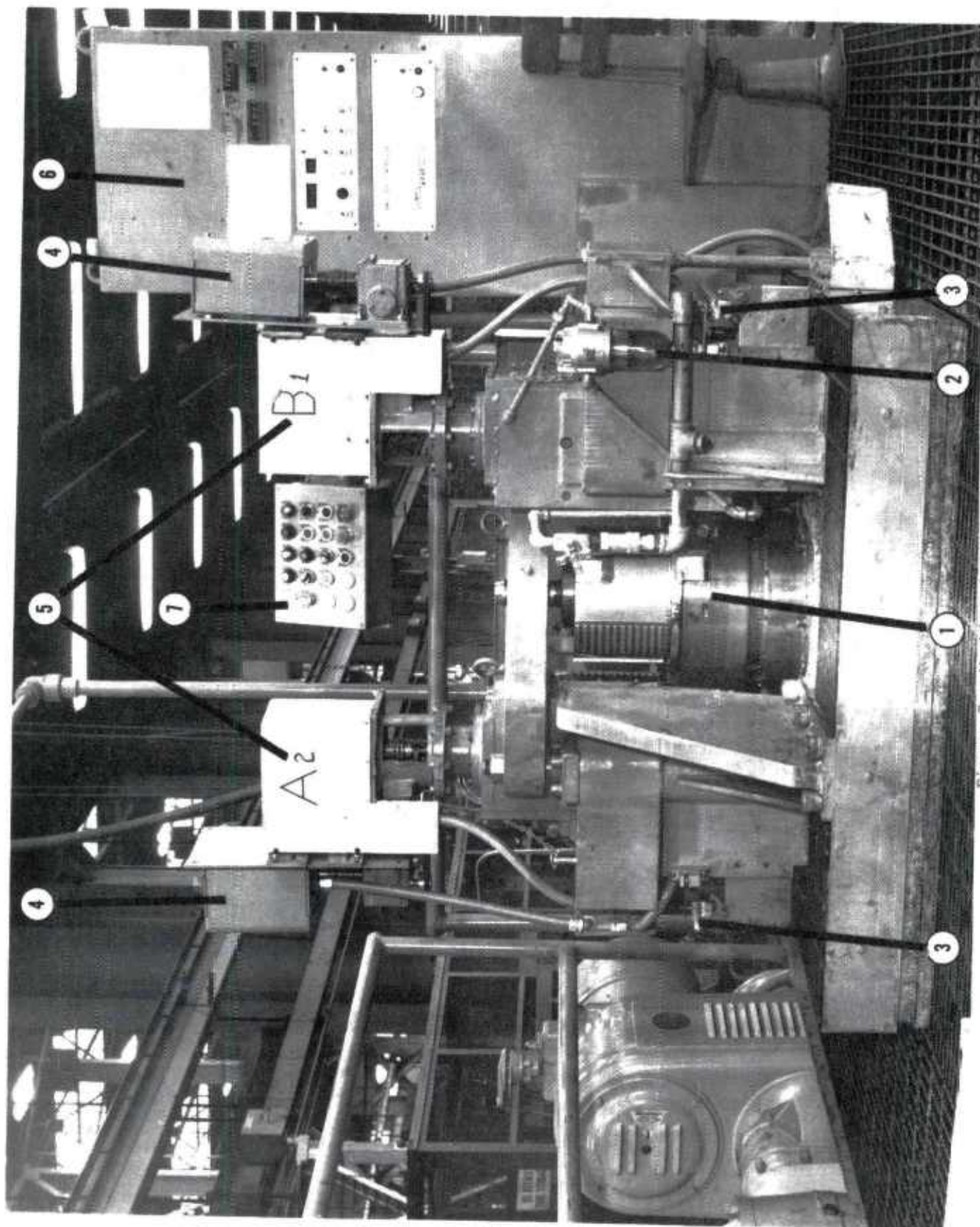


Figure 7. Machine (close-up).

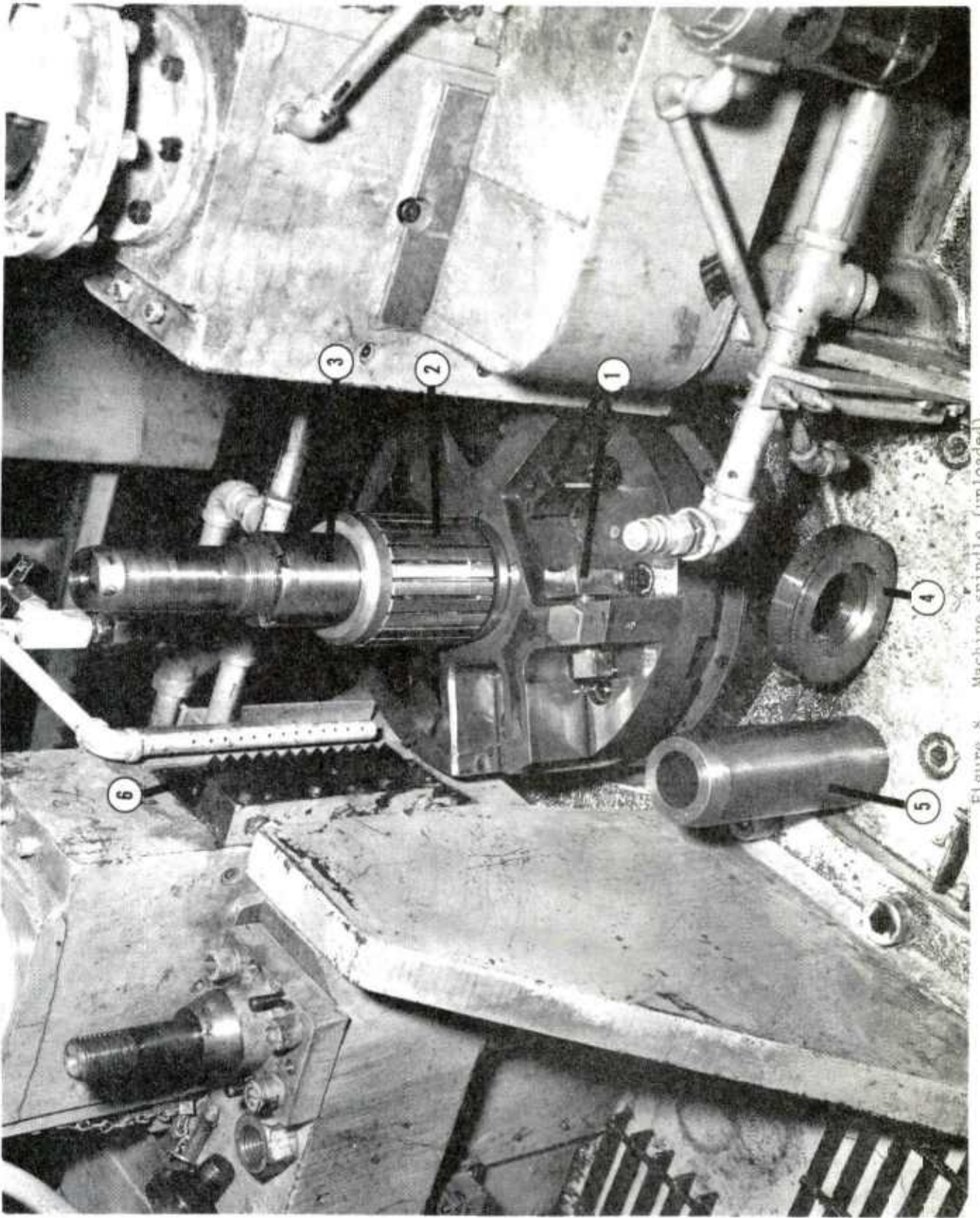


Figure 8. Machine spindle (unloaded).

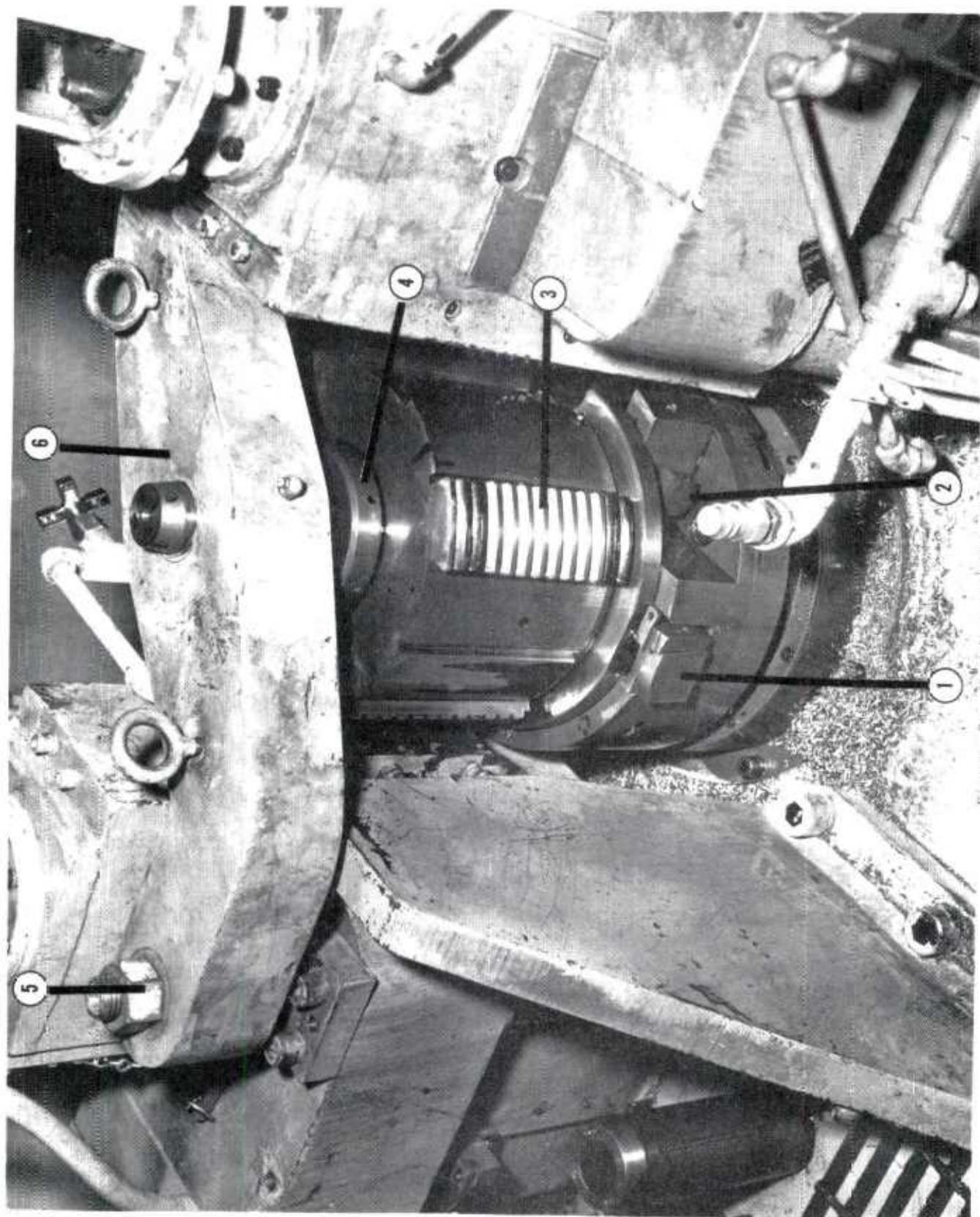


Figure 9. Machine spindle (loaded).

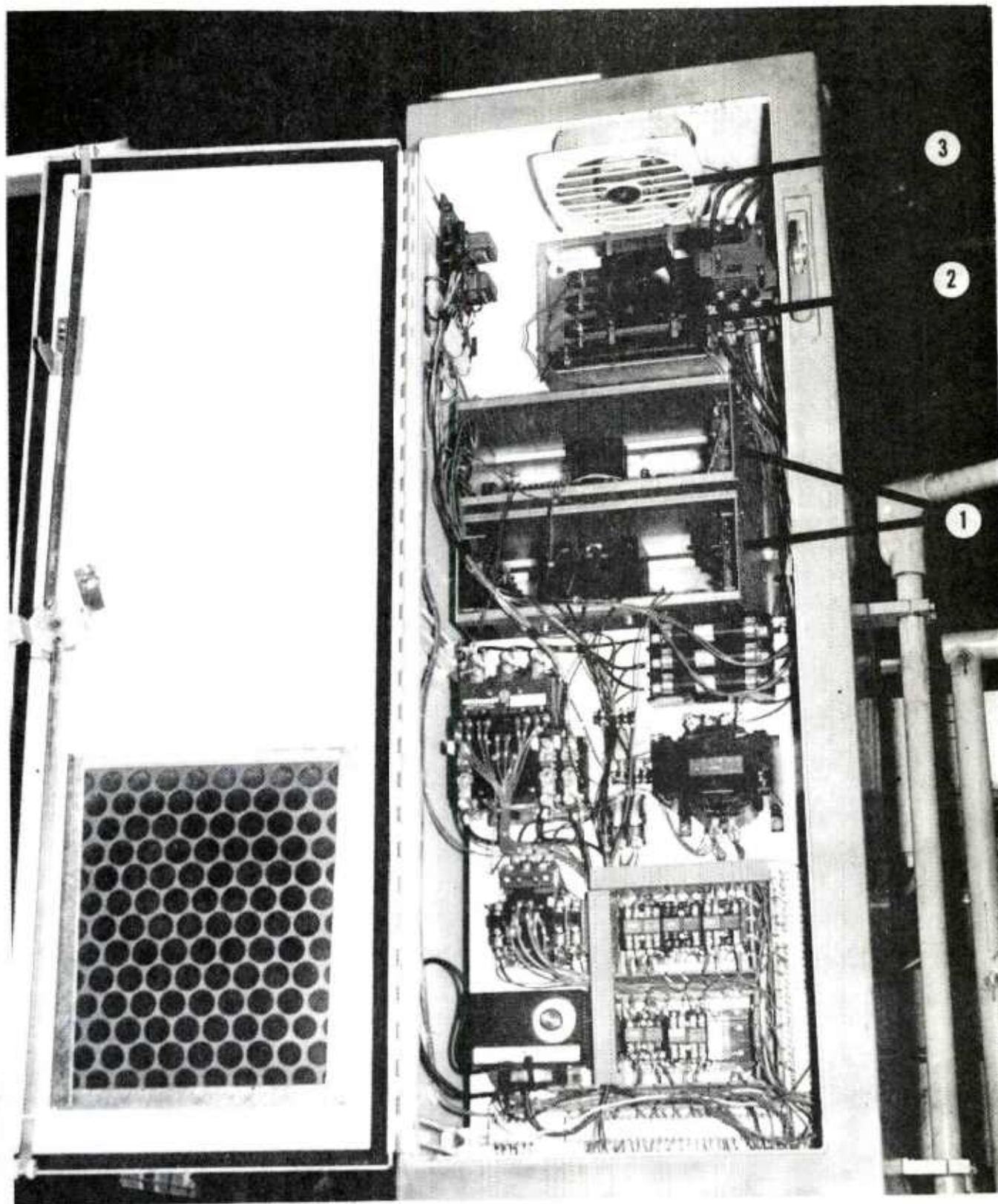


Figure 10. Electric panel.

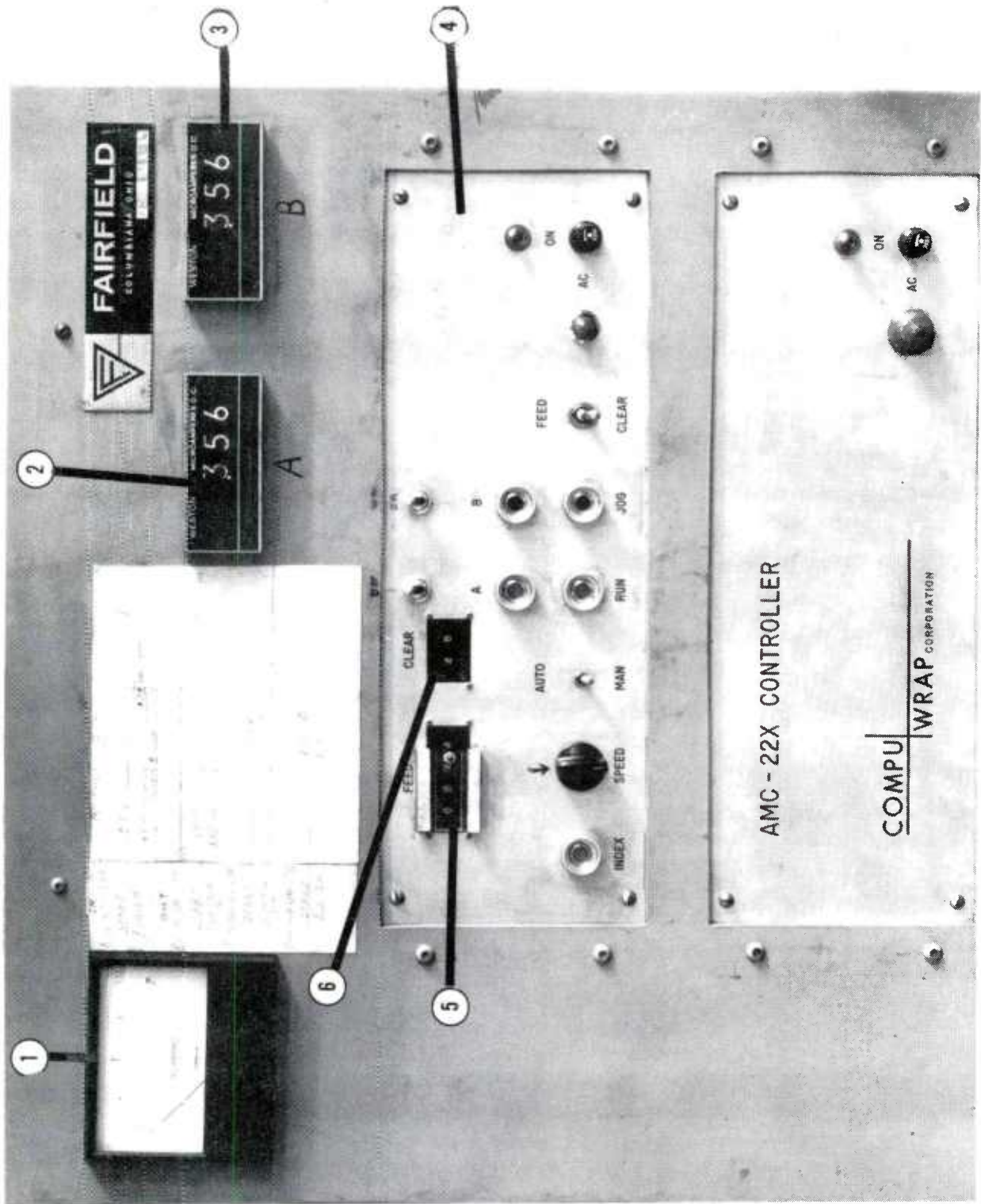


Figure 11. Machine console.

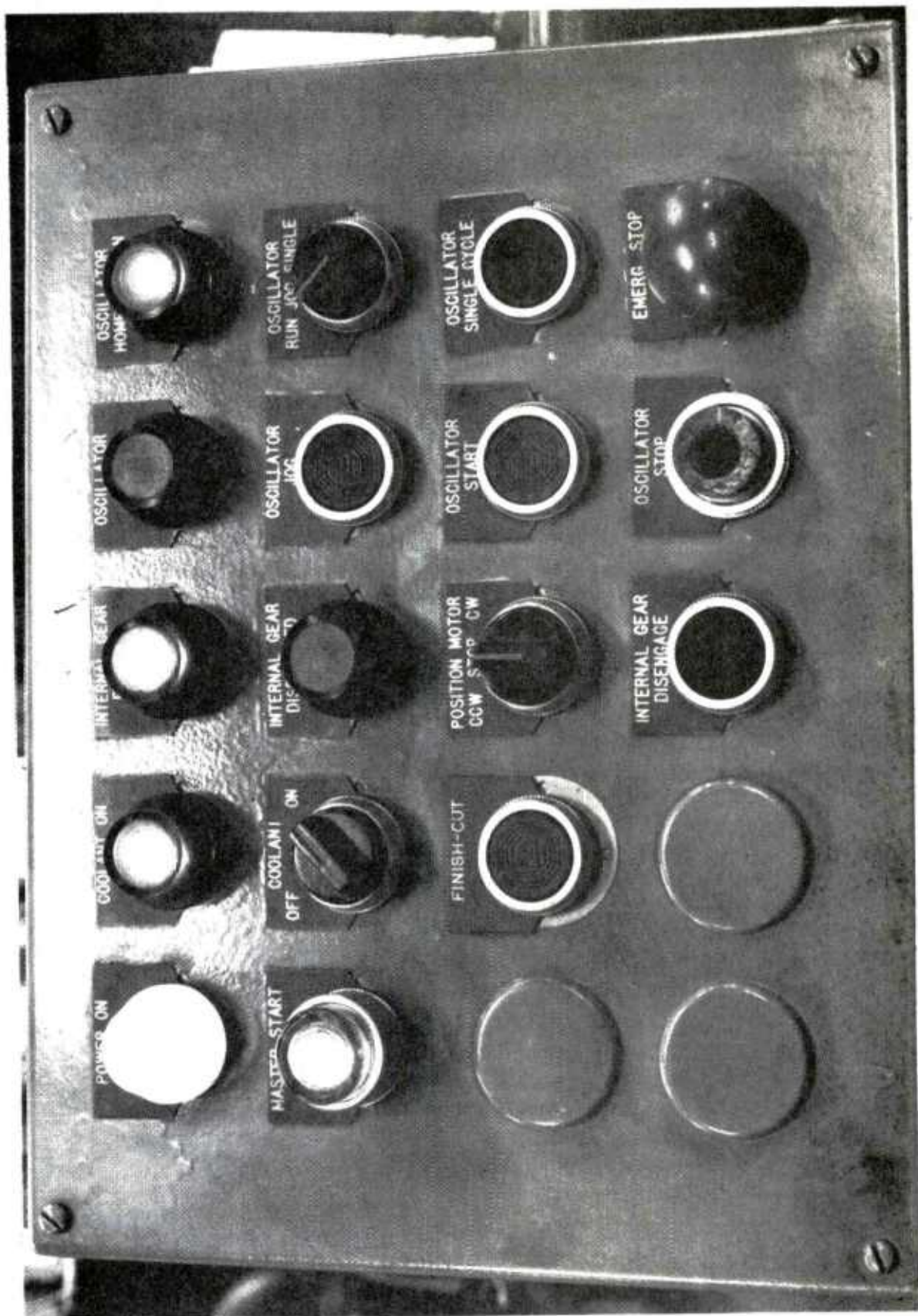


Figure 12. Operating panel.

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